DOCUMENT RESUME

ED 042 209 CG 005 747

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TITLE	Forecasting University Major with the Washington Pre-College Test Using Discriminant Functions.
INSTITUTION	Washington Univ., Seattle. Bureau of Testing.
PUB DATE	Jul 70
NOTE	20p.
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.10
DESCRIPTORS	*Academic Aspiration, Career Choice, *College Students, Decision Making, *Measurement Instruments, Occupational Choice, *Predictive Measurement, Test Construction, Testing, Tests, *Vocational Development

ABSTRACT

Formulae for discriminant functions were developed to permit future student users of the Washington Pre-College test battery to determine their similarity to successful University students graduating in 6 major areas - humanities, physical science, social science, business, biological science, and engineering. The sample studied consisted on 1,392 University of Washington students who graduated June, 1969. Utilization of these results is a first step towards the Washington Pre-College test helping students make more global and critical decisions such as academic vs. vocational program, college major, choice of occupation, etc. The future of this system will see the use of interest and self-expressions of choice as predictors and validation to determine the success of choosing to major in that group of greatest similarity to the individual. (Author)

ED042209

Forecasting University Major with the Washington Pre-College Test using Discriminant Functions

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CG 005 747

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University of Washington—Seattle

ED042209

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University of Washington

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Forecasting University Major with the Washington Pre-College Test using Discriminant Functions

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Formulae for discriminant functions were developed to permit future student users of the WPC battery to determine their similarity to successful University students graduating in 6 major areas--humanities, physical science, social science, business, biological science, and engineering. The sample studied consisted of 1,392 UW students who graduated June 1969. Utilization of these results is a first step towards WPC helping students make more global and critical decisions such as academic vs. vocational program, college major, choice of occupation, etc. The future of this system will see the use of interest and self-expressions of choice as predictors and validation to determine the success of choosing to major in that group of greatest similarity to the individual.

Bureau of Testing Project: 133

Forecasting University Major with the Washington Pre-College Test using Discriminant Functions

Predictions of graded success in a host of course areas have always characterized the Washington Pre-College (WPC) Testing Program and have afforded students a basis for making many specific decisions with respect to their college studies. For some time, however, there has also been interest in developing a system for making more global and critical decisions such as academic vs. vocational program, college major, choice of occupation, etc. The recent work of Stahmann (1966, 1969) indicated that best results in predicting eventual college major would be achieved utilizing multiple discriminant functions applied to entrance battery data including interest measures and self-expressions of choice. Although the present data base for graduating University of Washington (UW) students consists only of aptitude/achievement tests which are not as effective predictors of major as the above measures, it was decided to establish the system on these academic/achievement measures. Currently, the WPC battery includes the Vocational Interest Inventory as well as a comprehensive biographic survey, and data from these two sources will be available for all high school juniors tested spring 1970. When these students have completed college, their interest and biographic data will be used to improve the forecasting of major for subsequent generations.

The subjects for the present study were those 1,392 UW students who graduated in June 1969 who had taken the WPC battery and entered UW directly from high school. The group was 31% female (N = 434). Ss were divided into six groups on the basis of major: humanities (N = 285), physical science (N = 193), social science (N = 278), business (N = 123), biological science (N = 286) and engineering (N = 227).

The WPC variables included nine subtests--English usage, spelling, reading comprehension, vocabulary, mathematics achievement, applied mathematics, quantitative skills, space ability, and mechanical reasoning--and six high school GPA's--English, foreign language, social studies, mathematics, natural science, and electives.

Frequency distributions of the 15 WPC variables were obtained for each of the six major groups and decile norms calculated as reported in Tables 1 through 6. Decile norms for the total group appear in Table 7. Point-biserial correlations between each of the WPC variables and each major category are listed in Table 8. Variables stressing quantitative aptitude appear to correlate more highly with these major categories--positively with engineering and physical science and negatively with humanities. Engineering was marked by negative correlations with verbal aptitude which aptitude correlated close to zero with physical science.

Table 9 presents median scores for each of the six groups plotted against percentile norms developed by WPC for all freshmen entering the two state universities autumn 1969. Again, it is clear that quantitative performance tends to separate the major groupings more than other performances. Differences tended to be small and on reading comprehension all six groups had the same median score!

WPC data for the six major groups were then analyzed using the multiple discriminant function program outlined by Cooley & Lohnes (1962). Briefly, this technique defines first a linear function of the original variables such that the ratio of between groups variance to within groups variance on this derived measure is a maximum. This derived measure is the best single

Table 1

Deciles in Standard Score Form for Graduating (1969) University of Washington Humanities Majors

(N = 285)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	69	70	74	72	69	66	65	69	65				3.9		
80	66	65	70	68	65	64	61	62	60	3.9			3.6	3.9	
70	64	62	65	65	61	61	59	60	56	3.8	3.8	3.9	3.4	3.6	3.9
60	62	60	62	62	59	59	56	58	53	3.7	3.6	3.7	3.2	3.5	3.8
50	60	58	59	59	56	57	54	56	52	3.5	3.4	3.5	3.1	3.4	3.7
40	56	55	57	57	53	55	51	53	49	3.4	3.2	3.4	2.9	3.1	3.5
30	53	52	54	55	51	51	50	51	47	3.1	3.1	3.3	2.6	3.0	3.4
20	51	49	51	51	47	49	46	47	44	3.0	2.8	3.1	2.4	2.7	3.1
10	47	46	46	47	44	46	44	42	42	2.7	2.4	2.8	2.1	2.4	2.9
$\bar{X}$	62	57	58	61	55	54	54	53	52	3.3	3.3	3.4	2.9	3.2	3.5
SD	8.9	9.8	10.8	9.6	9.6	8.6	8.6	8.9	9.5	.55	.67	.53	.65	.64	.51

Table 2

Deciles in Standard Score Form for Graduating (1969) University of Washington Physical Science Majors

(N = 193)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	68	71	74	70	76	76	74	73	76						
80	66	66	70	68	73	72	70	69	72	3.8					
70	64	61	65	64	71	70	66	67	68	3.6	3.9	3.8	3.9	3.9	3.9
60	61	58	62	60	70	68	64	65	64	3.5	3.6	3.7	3.8	3.7	3.8
50	58	56	60	58	68	64	62	62	61	3.4	3.4	3.6	3.6	3.6	3.6
40	56	53	59	55	65	62	61	60	59	3.1	3.1	3.5	3.4	3.4	3.4
30	53	50	56	53	62	61	58	58	56	3.0	3.0	3.3	3.1	3.1	3.3
20	49	48	53	50	60	59	56	56	53	2.9	2.6	3.1	2.9	2.9	3.1
10	48	43	48	46	55	55	52	49	49	2.6	2.3	2.8	2.5	2.6	2.7
$\bar{X}$	61	55	59	60	66	63	62	59	63	3.2	3.2	3.4	3.3	3.4	3.4
SD	8.9	10.4	10.2	9.4	8.0	9.1	8.6	8.5	10.1	.54	.75	.53	.62	.64	.70

Table 3

Deciles in Standard Score Form for Graduating (1969) University of Washington Social Science Majors

(N = 278)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	67	68	74	68	71	72	68	67	68				3.9		
80	64	65	68	65	68	68	65	65	64	3.8	3.9		3.6	3.7	3.9
70	61	61	65	62	65	66	61	60	60	3.6	3.6	3.9	3.4	3.6	3.8
60	59	58	60	59	61	62	59	58	56	3.4	3.4	3.6	3.3	3.4	3.6
50	57	55	59	57	59	59	58	56	53	3.3	3.2	3.5	3.1	3.3	3.4
40	56	52	56	55	56	57	55	53	51	3.2	3.1	3.4	2.9	3.1	3.3
30	52	51	54	52	53	55	52	51	48	3.1	2.9	3.1	2.8	3.0	3.1
20	49	48	51	50	50	51	50	49	45	2.9	2.6	2.9	2.6	2.7	3.0
10	46	43	46	46	46	47	46	42	43	2.7	2.2	2.6	2.3	2.4	2.6
$\bar{X}$	60	55	58	59	58	57	57	53	55	3.2	3.1	3.4	3.0	3.1	3.2
SD	8.9	9.8	10.0	9.0	9.9	9.3	8.8	8.7	10.5	.48	.67	.54	.58	.59	.80

Table 4

Deciles in Standard Score Form for Graduating (1969) University of Washington Business Majors

(N = 123)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	65	66	68	67	70	72	70	67	71	3.9				3.9	
80	62	64	65	62	69	70	66	62	65	3.7	3.9	3.9	3.8	3.6	3.9
70	59	60	62	60	66	66	64	60	63	3.5	3.7	3.8	3.6	3.4	3.8
60	56	58	60	57	64	64	61	58	60	3.4	3.4	3.6	3.4	3.3	3.6
50	54	55	59	55	62	62	59	56	57	3.2	3.2	3.5	3.1	3.1	3.5
40	52	51	56	53	60	61	58	53	55	3.1	3.0	3.4	3.0	3.0	3.4
30	50	49	53	51	56	57	56	51	52	3.0	2.6	3.2	2.8	2.9	3.1
20	48	47	51	49	53	55	53	49	48	2.9	2.4	3.1	2.6	2.8	3.0
10	45	43	48	46	49	51	51	45	44	2.6	2.3	2.9	2.4	2.4	2.9
$\bar{X}$	57	54	56	57	61	60	59	54	57	3.2	3.0	3.4	3.1	3.1	3.3
SD	8.3	8.9	8.5	8.2	8.8	8.5	7.9	8.5	9.8	.46	.72	.45	.62	.55	.62

Table 5

Deciles in Standard Score Form for Graduating (1969) University of Washington Biological Sciences Majors

(N = 286)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	67	70	74	70	72	74	69	69	72						
80	65	67	68	64	69	68	65	65	65	3.9			3.9	3.9	
70	62	61	63	62	67	66	63	62	61	3.7	3.9	3.9	3.7	3.8	3.9
60	60	59	62	59	65	64	60	60	59	3.6	3.6	3.7	3.4	3.6	3.8
50	58	56	59	56	62	61	58	58	55	3.4	3.4	3.6	3.3	3.5	3.6
40	56	53	56	54	60	59	57	56	52	3.3	3.2	3.4	3.1	3.3	3.5
30	53	51	54	52	57	57	55	51	51	3.1	3.1	3.2	2.9	3.1	3.4
20	51	48	51	51	53	53	52	49	47	3.0	2.8	3.1	2.8	2.9	3.1
10	47	46	48	47	49	49	49	[illegible]	43	2.8	2.4	2.9	2.4	2.6	2.8
$\bar{X}$	60	56	58	59	61	58	58	[illegible]	57	3.3	3.2	3.4	3.2	3.3	3.4
SD	8.6	10.1	10.1	9.1	9.0	9.3	8.1	8.4	11.2	.53	.69	.52	.60	.60	.73

Table 6

Deciles in Standard Score Form for Graduating (1969) University of Washington Engineering Majors

(N = 227)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	66	66	70	66	75	74	71	73	77	3.8					
80	62	61	65	62	72	72	69	69	72	3.6	3.9	3.9	3.9		4.0
70	59	58	62	60	71	68	66	65	69	3.4	3.6	3.8	3.8	3.8	3.8
60	57	55	60	57	69	66	65	62	68	3.3	3.4	3.6	3.7	3.6	3.7
50	55	52	59	55	68	64	63	60	65	3.2	3.2	3.5	3.6	3.5	3.5
40	52	50	57	52	66	62	60	58	63	3.1	3.0	3.4	3.3	3.3	3.4
30	50	48	53	51	64	61	58	56	60	2.9	2.9	3.1	3.1	3.1	3.1
20	47	46	50	49	61	57	57	53	56	2.8	2.5	3.0	3.0	3.0	3.0
10	44	41	46	45	58	55	53	51	52	2.5	2.1	2.8	2.8	2.7	2.8
$\bar{X}$	57	52	57	56	67	62	62	59	65	3.1	3.1	3.3	3.4	3.3	3.3
SD	9.0	9.2	9.3	8.8	6.9	7.9	7.5	7.9	9.8	.50	.67	.50	.49	.55	.69

Table 7

Deciles in Standard Score Form for Graduating (1969)

University of Washington Seniors

(N = 1392)

	EU	SP	RC	Voc	MA	AM	QST	SA	MR	Engl GPA	FL GPA	SS GPA	Math GPA	NS GPA	Elect GPA
90	67	69	73	69	73	74	70	69	72	4.0					
80	65	65	68	66	70	68	66	67	68	3.8	3.9	4.0	3.8	3.9	4.0
70	62	61	63	62	68	66	63	62	64	3.6	3.8	3.9	3.6	3.7	3.9
60	59	58	62	60	65	64	61	60	60	3.5	3.6	3.7	3.4	3.6	3.7
50	57	56	59	57	62	61	58	58	56	3.4	3.4	3.6	3.3	3.4	3.6
40	55	52	57	55	60	59	57	56	53	3.2	3.1	3.4	3.1	3.1	3.4
30	52	50	54	52	56	57	54	53	51	3.1	2.9	3.2	2.9	3.0	3.3
20	49	48	51	50	53	53	51	49	48	2.9	2.6	3.1	2.7	2.8	3.1
10	46	43	46	46	48	49	48	47	44	2.6	2.1	2.8	2.4	2.6	2.8
$\bar{X}$	60	55	58	59	61	58	58	55	58	3.2	3.2	3.4	3.1	3.2	3.4
SD	9.0	9.9	10.0	9.2	9.8	9.3	8.9	8.8	11.2	.52	.70	.52	.62	.61	.69

Table 8

Point Biserial Correlation Coefficients between the Washington Pre-College Battery and Graduating Major at the University of Washington, 1969

(N = 1392)

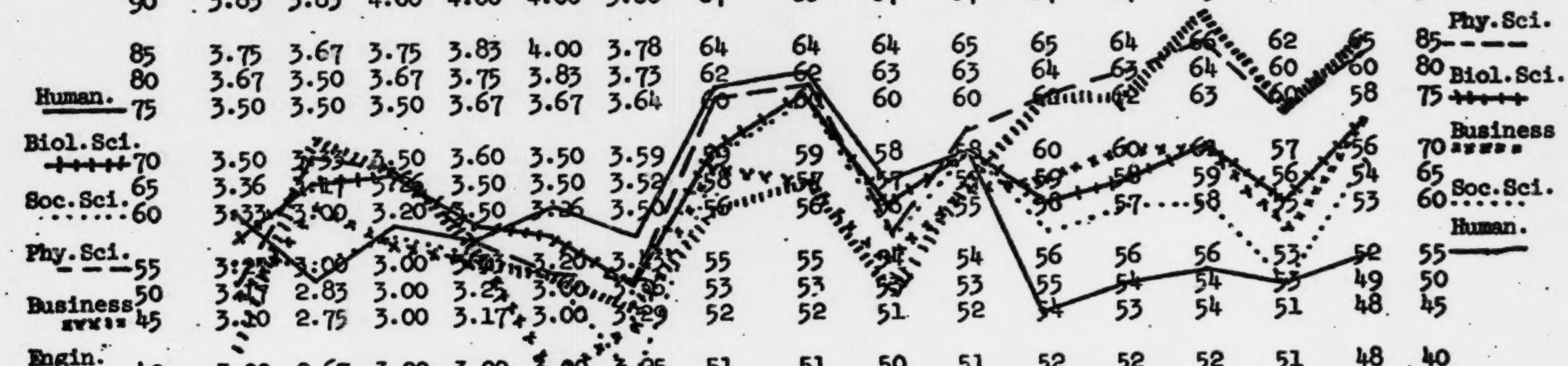
	Humanities	Phy. Science	Soc. Science	Business	Biol. Sci.	Engineering
EU	.1071	.0480	-.0100	-.0930	.0408	-.1188
SP	.0867	.0000	-.0100	-.0372	.0510	-.1232
RC	.0255	.0480	.0000	-.0434	.0051	-.0396
Voc	.1275	.0400	-.0217	-.0651	.0051	-.1100
MA	-.2907	.2120	-.1350	-.0124	.0051	.2552
AM	-.2601	.1760	-.0650	.0372	.0000	.1540
QST	-.2703	.1800	-.0900	.0310	-.0051	.1980
SA	-.1617	.1720	-.1150	-.0527	-.0153	.1584
MR	-.2448	.1800	-.1400	-.0124	-.0510	.2904
Engl. GPA	.1071	-.0160	.0100	-.0403	.0612	-.1452
For. Lang. GPA	.0714	.0040	-.0450	-.0837	.0663	-.0572
Soc. Sci. GPA	.0102	.0080	-.0300	-.0062	.0408	-.0440
Math GPA	-.1785	.1360	-.1150	-.0403	.0306	.1716
Nat. Sci. GPA	-.0510	.0840	-.0800	-.0775	.0561	.0792
Elect. GPA	.0832	.0160	-.0850	-.0093	.0153	-.0176

Table 9

Median WPC Scores for Six Groups of University of Washington Senior Majors, 1969,

Using Percentiles for Washington State Universities' Entering Freshmen, 1969

% ILE	Engl GPA	Math GPA	Nat Sci GPA	Soc Sci GPA	For Lang GPA	Elec- tives GPA	Vocab- ulary Score	Engl Usage	Spel- ling	Read Comp	Quan Skil	Appl Math	Math Ach	Spat Abil	Mech Reas	% ILE
99	4.00	4.00	4.00	4.00	4.00	4.00	75	75	77	80	75	77	75	72	79	99
95	4.00	4.00	4.00	4.00	4.00	4.00	70	69	71	71	70	71	71	68	70	95
90	3.83	3.83	4.00	4.00	4.00	3.88	67	66	67	67	67	67	69	64	66	90
85	3.75	3.67	3.75	3.83	4.00	3.78	64	64	64	65	65	64	66	62	65	85
80	3.67	3.50	3.67	3.75	3.83	3.73	62	62	63	63	64	63	64	60	60	80
75	3.50	3.50	3.50	3.67	3.67	3.64	60	60	60	60	62	62	63	60	58	75
70	3.50	3.33	3.50	3.60	3.50	3.59	59	59	58	58	60	60	62	57	56	70
65	3.36	3.17	3.56	3.50	3.50	3.52	58	57	57	56	59	58	59	56	54	65
60	3.33	3.00	3.20	3.50	3.36	3.50	56	56	55	56	58	57	58	55	53	60
55	3.25	3.00	3.00	3.43	3.20	3.43	55	55	54	54	56	56	56	53	52	55
50	3.17	2.83	3.00	3.25	3.00	3.36	53	53	53	53	55	54	54	53	49	50
45	3.10	2.75	3.00	3.17	3.00	3.29	52	52	51	52	54	53	54	51	48	45
40	3.00	2.67	3.00	3.00	3.00	3.25	51	51	50	51	52	52	52	51	48	40
35	3.00	2.50	2.75	3.00	2.75	3.15	50	50	49	49	52	50	51	49	46	35
30	2.83	2.50	2.60	3.00	2.67	3.08	48	48	48	48	50	48	49	47	45	30
25	2.76	2.33	2.50	2.76	2.50	3.00	47	47	46	46	48	48	48	46	44	25
20	2.67	2.25	2.50	2.67	2.50	2.93	46	46	45	45	47	46	46	45	42	20
15	2.50	2.00	2.25	2.50	2.25	2.80	44	44	44	43	45	44	44	43	39	15
10	2.33	2.00	2.00	2.33	2.00	2.67	43	42	41	42	42	43	42	39	38	10
5	2.17	1.67	2.00	2.13	1.75	2.50	40	39	38	38	39	39	40	34	38	5
1	1.67	1.20	1.33	1.75	1.00	2.00	34	34	34	34	34	33	36	28	38	1
Mean	3.12	2.85	2.99	3.19	3.04	3.29	53.9	53.8	53.5	53.8	54.9	54.4	55.1	52.1	51.6	Mean
SD	.57	.73	.69	.62	.77	.52	9.5	9.6	10.1	10.2	9.9	9.8	10.0	10.1	10.8	SD



measure for discriminating between the groups. A second and additional linear functions, uncorrelated with the first, are then obtained until all of the between groups variance for predictor variables is accounted for. In the present study two discriminant functions were sufficient to account for 92.3 percent of the variance and hence only these two functions were developed for prediction purposes. Discriminant functions are weighted combinations of a set of predictor variables which produce new scores for each individual in a sample or subsequent samples. The new scores are used to decide to which of several groups an individual is most similar. Discriminating the "right" group of an individual is important because treatment of one sort or another is to follow. By choosing the group to which he is most similar in terms of the discriminant functions the individual will be more likely to benefit from treatment. Wherever there is a need to assign people to diagnostic categories, training programs, jobs, work settings, etc., this technique allows the most efficient use of available predictor data. Validation in a new sample calls for comparing the success rates for those individuals entering the treatment indicated by the discriminant function with that for those individuals who were assigned or chose to take an alternative treatment.

The two discriminant functions obtained in this study are described in Table 10. The standardized weights given for each of the functions indicate the relative contribution of WPC variables to those functions. Thus, the first discriminant function gives strong positive weight to mechanical reasoning and mathematics achievement and strong negative weight to vocabulary and to high school English GPA. The second discriminant function is positively determined by tests of applied mathematics and quantitative skills and negatively by spatial ability and mathematics achievement. How the major groups

Table 10

Weights of Washington Pre-College Variables in Determining First and Second Discriminant Functions[1]

Variable	Weights: Function 1(X_1) Standardized	Conventional	Weights: Function 2(X_2) Standardized	Conventional
English Usage	-.292	-.033	-.252	-.028
Spelling	.005	.001	-.045	-.005
Reading Comprehension	-.036	-.004	.126	.013
Mechanical Reasoning	.457	.043	-.170	-.016
Spatial Ability	-.091	-.010	-.377	-.043
Applied Mathematics	.185	.020	.293	.032
Vocabulary	-.359	-.039	-.228	-.025
Math. Achievement	.515	.053	-.288	-.030
HS English GPA	-.352	-.644	.195	.357
HS For. Lang. GPA	-.035	-.043	-.256	-.313
HS Math. GPA	.286	.433	-.043	-.065
HS Nat. Sci. GPA	.139	.232	-.278	-.464
HS Soc. Sci. GPA	.008	.014	.117	.200
HS Electives GPA	-.033	-.060	-.172	-.313
Quantitative Skills	.202	.023	.544	.063
Additive Constant	5.995	3.059	5.105	9.303

[1]Standardized weights assume all variables have a common mean of 5.0 and a common variance of 1.0. Conventional weights assume WPC variables in their usually reported form, i.e., test scores with means of 50 (SD = 10) and HS GPA's of the form 4.0 = A, 3.0 = B, etc.

are separated is depicted in Figure 1. The six points correspond to the centroids of the six majors, i.e., to the average score on the discriminant functions for the six groups. On the first discriminant function lowest scores were earned by humanities majors and highest scores by engineers. On the second function lowest scores were associated with majoring in humanities again and in physical science and highest scores with business. Figure 1 illustrates how additional functions provide less discrimination between the groups--note that the centroids for the majors are more separated horizontally for the first function than vertically for the second.

Computing discriminant scores for a student from a subsequent sample would describe a point which could be plotted onto Figure 1 and used to decide to which major group the student was closest. This primitive use of the discriminant function is greatly improved by computer availability. By knowing the distribution of discriminant function scores for each of the major groups it is possible to calculate, given discriminant function scores for a new individual, the probability that he 'belongs' to each of the groups. Thus, the major group to which a student is most similar is that group with the highest probability.

The calculation of these probabilities for current groups of high school students being tested by the WPC program could be based on the formulae given in Table 11. For each of the six majors an equation is presented in which the two discriminant functions (X_1 and X_2), their squares and their products, are weighted to provide a chi-square value. The chi-square values are for that statistic with 1 degree of freedom and could easily be converted to the desired probabilities. This latter step is not necessary if all that is wanted is a ranking of the major groupings from most similar to least

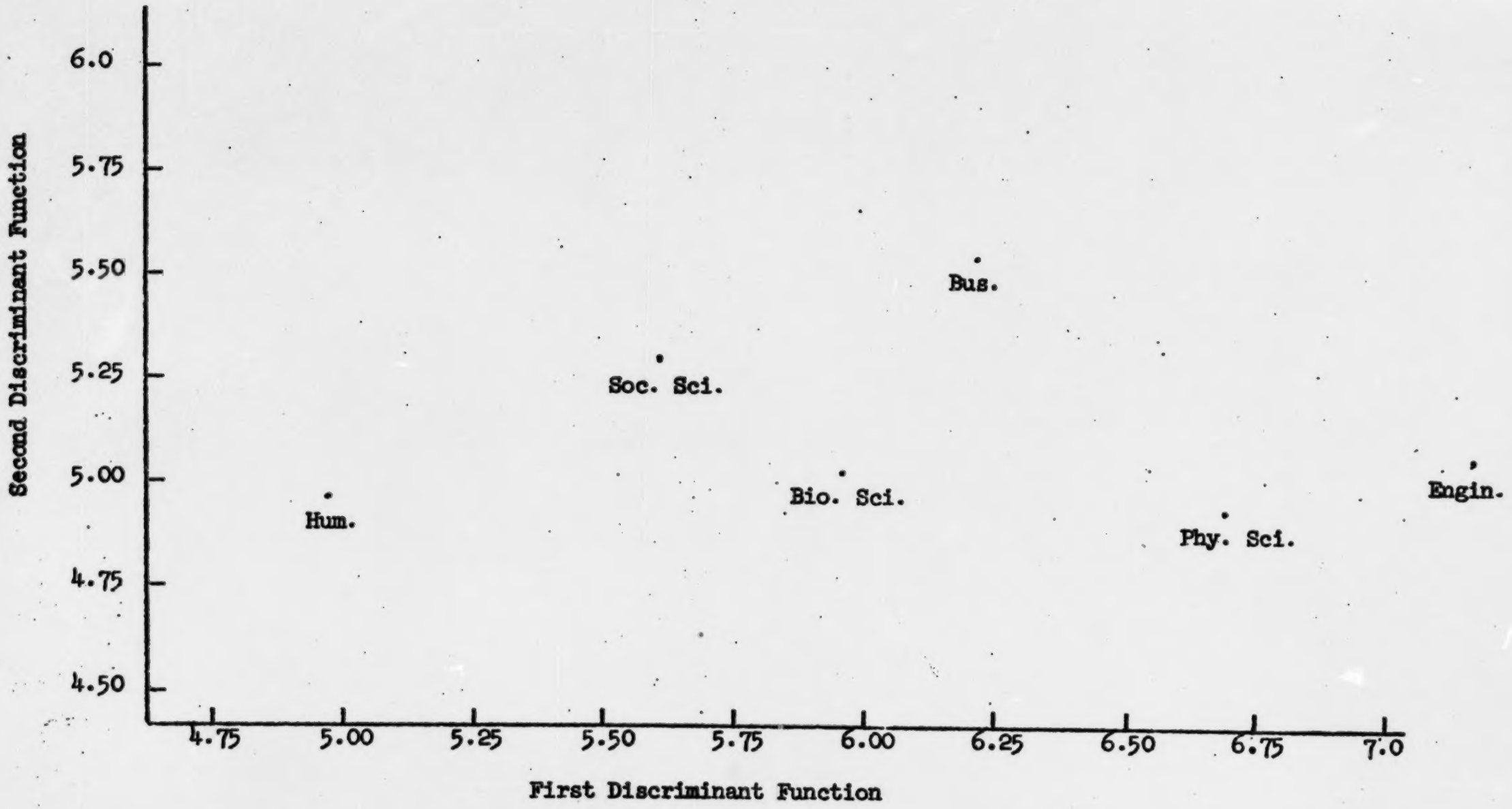


Fig. 1. Centroids of Six Major Groups on First Two Discriminant Functions.

Table 11

Constants for Predictive Functions for College Major Groups Utilizing First and Second Discriminant Functions[1]

x^2 Predictive Function for Individual

$$x_g^2 = aX_1^2 + bX_2^2 + cX_1 + dX_2 + eX_1X_2 + f$$

Group (g)	Constants for the Predictive Function					
	a	b	c	d	e	f
1. Humanities	.82	1.84	-7.93	-18.02	-.05	64.44
2. Phys. Sci.	1.03	1.63	-13.29	-15.37	-.10	82.11
3. Social Sci.	.76	1.55	-8.48	-16.26	-.01	66.79
4. Business	1.02	1.77	-14.53	-21.83	.35	105.50
5. Biolog. Sci.	.79	1.66	-9.53	-16.83	.03	70.41
6. Engineering	1.17	1.97	-16.34	-19.47	-.07	107.56

[1]The group for which an individual's x^2 value is smallest represents the group to which he is most similar.

similar. The most similar group will yield the smallest chi-square value and the least similar the largest. It is suggested that the computation of the discriminant functions and major group chi-square values be undertaken for all WPC testees and that those who intend to obtain a bachelor's degree or above be provided beginning autumn 1970 (i.e., juniors tested spring 1970), a ranking of their similarities to successful University majors of the six broad categories studied here. In addition to restricting forecasts of major to B. A. aspirants, the rankings of the six majors should include for each major one of the following adjective labels--"very similar," "somewhat similar," "slightly similar," and "not similar." These labels correspond to the four quartiles of probabilities behind the rankings. By attaching these qualifications to the rankings students for whom all probabilities are low will not be misled into choosing a major on this basis.

This major forecasting output could be combined with the results of the biographic survey and Vocational Interest Inventory which have been planned to be reported in autumn 1970 as well. In addition, the WPC program might also wish to make some use of the decile data included here, for example, Table 9, in the guidance information it provides.

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